



## Section 2.1 General

The operation of a High-Occupancy Vehicle (HOV) facility is closely linked to its design features and the traffic demands on the freeway corridor. Therefore, operational characteristics must be considered not only during the design process, but also for HOV system planning. As recommended for design features, operational characteristics should also be uniform and consistent within a region.

In areas where the central business district is less identifiable and consists of pockets of intensive business activity distributed over a wide area, sometimes called a “suburban” geographical area, the commute pattern is less definitive and the directional traffic split is more equal than that of the “radial” geographical area. For the suburban geographical area, a two-way flow is preferable and reversible HOV operation would not be appropriate.

When a metropolitan area largely consists of a central business district with weekday commuter traffic from outlying areas, often referred to as a “radial”

geographical area, the traffic demands on each corridor normally would indicate definite directional peaks during the morning and afternoon commute periods. If traffic in the off-peak direction is light (35% or less of the total freeway traffic during the peak periods) and is forecast to remain light during the design life of the project, then a reversible HOV operation may be appropriate. Since barrier-separated facilities offer features suitable for a reversible operation, it would be one of the logical candidates for initial consideration.

As discussed in Chapter 3, “HOV Geometric Design” facilities can be barrier-separated, buffer-separated or contiguous. The different modes of operation and their applicability with each type of geometric configuration will be addressed below.

## Section 2.2 Modes of Operation

HOV facilities can be operated with two-way flow, reversible flow, or contraflow.

### Section 2.2.1 Two-Way Flow

Two-way flow HOV operation is appropriate when the existing peak period directional traffic is 35/65 or more evenly split and is expected to remain so during the design life of the project. It is the predominant mode of operation for the Department's HOV facilities.

When right of way and cost constraints allow, a two-way barrier-separated HOV facility, with a physical barrier separating the HOV lanes from the mixed-flow lanes generally offers a higher level of service than other geometric configurations (See Chapter 3). A portion of the El Monte Busway (LA-10) near Los Angeles is one example of this type of facility.

Operating data indicates that busways experience congestion at about 1,500 vehicles per hour. Therefore, consideration has been given to using a three plus (3+) occupancy requirement or to having more than one HOV lane in each direction when traffic exceeds this number. Because of potential visibility problems between buses and motorcycles, exclusion of motorcycles on HOV facilities with high bus volumes may be appropriate. However, such exclusions are only allowed if a documented study for that specific HOV facility indicates that motorcycle use constitutes a safety hazard and the exclusion is approved by the Federal Highway Administration.

### Section 2.2.2 Reversible Flow

Reversible flow is an operational mode where the HOV lanes operate in one direction during the AM peak period and change to the opposite direction during the PM peak period. This type of operation is feasible only if the existing and forecast peak period directional traffic split is 35% or less in one direction during the design life of the project. Other factors, which could support the use of a reversible flow operation, are right of way constraints and physical constraints, such as bridge columns, in retrofitting a reversible flow operation into the median.

Reversible flow operation should only be used on barrier-separated HOV facilities with limited ingress/

egress to the HOV lanes (See Chapter 3). Its operation can be expensive in terms of equipment and manpower. Also, a reversible facility is functional only during peak periods due to required preparations for each directional change.

### Section 2.2.3 Contraflow

A contraflow HOV facility uses the excess freeway capacity in the off-peak direction to relieve congestion in the direction of peak flow. With median crossovers, traffic is guided across the median to the inside lane in the opposite direction. Typically, removable pylons, movable barriers or an additional lane is used to separate the contraflow lane from the adjacent mixed-flow lanes. It should only be considered: (1) if the peak period directional traffic split is 35% or less during the design life of the project, and (2) if the speed of the opposing mixed-flow traffic is not reduced by implementation of the contraflow lane.

Between 1974 and 1986, Caltrans operated a bus-only contraflow facility on 4 miles of Route 101 in Marin County, north of San Francisco. The facility, which allowed buses with permits to bypass congestion and go directly into a contiguous HOV lane, used two lanes from the southbound (off-peak) direction with one of the lanes acting as a buffer. The contraflow lane was discontinued after freeway improvements reduced congestion and speeds in the mixed-flow lanes increased to match that of the contraflow lane.

It is unlikely that the contraflow operational mode will be used extensively in California. In most of the State's metropolitan areas, taking an additional lane for a buffer creates an unacceptable level of service for the opposing traffic. Movable barriers or pylons eliminate the need for a buffer lane but their use requires a set-up and take-down process which is costly and which causes potential conflicts between motorists and the placement crew.

### Section 2.3 Queue Bypasses

HOV queue bypasses are relatively short sections of HOV lanes, which bypass congestion and provide

significant timesavings for carpools, vanpools and buses. Examples of queue bypasses in California are bridge toll plaza bypass lanes and ramp meter bypass lanes. They are not associated with any particular geometric configuration and need to be designed for specific sites. For ramp meter bypass lanes, refer to the Department's "Ramp Meter Design Guidelines" prepared by Headquarters Division of Traffic Operations.

## Section 2.4 Hours of Operation

The determination of whether HOV lanes should be operated part or full-time, from a traffic-operational viewpoint, should be largely a matter of congestion and the length of peak period and off-peak periods. The decision whether to operate on a part-time or on a full-time basis hinges on other factors as well. The factors include traffic safety, political and public considerations, air quality concerns, enforcement issues, and geographical dispersions of trip patterns (radial routes to or from a central business district or a suburban grid pattern with multiple business districts). Most of all, the need to maintain consistent and uniform HOV operation on a corridor by corridor basis is required as well as an ultimate region-wide basis to avoid motorist confusion.

### Section 2.4.1 Peak Period Operation

Peak period operation has the following benefits:

- A. Avoid the public perception that the HOV lane is underutilized (the "empty lane syndrome") during off-peak periods, particularly if public sentiment is not totally receptive to the HOV project.
- B. Freeway lane densities are lower during off-peak periods, thus providing a higher LOS.
- C. Lane closures during the off-peak for maintenance creates less congestion due to the availability of the additional lane.

Northern California commute patterns generally consist of two short definable peak commute periods (two to four hours during the mornings and evenings) separated by a long mid-day off-peak period. Traffic-flow characteristics in Northern California are conducive to part-time operation during peak hours with unrestricted access. All part-time HOV facilities in the state are contiguous, which means that the HOV lane is separated from the adjacent mixed-flow lanes by the same broken white line or reflective marker pattern used on the majority of mixed-flow lanes. The HOV lane traffic is free to enter and exit the lane throughout the length of the facility. Part-time HOV facilities provide optimum use of all lanes during off-peak periods, particularly for construction and maintenance purposes.

### Section 2.4.2 Continuous HOV Operation

Compared to a peak period operation, continuous HOV operation presents the following benefits:

- A. Signing and delineation are simpler.
- B. Violation rates tend to be lower and enforcement is easier.
- C. There is less motorist confusion concerning operational hours.
- D. Since continuous HOV operation occurs frequently on buffered or barrier-separated facilities, freeway incidents are less likely to affect HOV lane operation.
- E. Since the ridesharing concept is encouraged at all times of the day, there could be a greater mode shift to ridesharing.
- F. Continuous HOV operations can be applied on all types of geometric configurations.

The Southern California commute and peak hours, both in the morning and the evening, (typically between six to

eleven hours) are much longer and separated by a short off-peak period. All, with one exception, full-time HOV facilities in the state are buffered, which means that the HOV lane is separated from the adjacent mixed-flow lanes by a combination of reflective markers and solid yellow and white painted stripes per the California Vehicle Code. These facilities offer restricted access entrances and exits which are clearly delineated with a broken white line. Only one full-time HOV facility, the El Monte Busway on Interstate 10 in Los Angeles County, is barrier separated.

## Section 2.5 Vehicle Occupancy

The occupancy requirements for HOV facilities should be based on the following considerations:

- A. Maximizing the person-per-hour throughput.
- B. Allowing for HOV growth and increased usage of the HOV facility.
- C. Maintaining a free-flow condition, preferably a LOS-C.
- D. Conforming to the occupancy requirements of the region, particularly connecting HOV routes.
- E. Completion of a region's HOV system or adjacent HOV facilities could redistribute the HOV traffic, thereby making occupancy adjustments unnecessary.
- F. Adjust occupancy requirements to avoid the perception of lane underutilization.

The predominant occupancy requirement for existing HOV facilities is two plus (2+) and it is expected that most new HOV facilities will be 2+ as well. However, as some existing HOV facilities have become congested, the District should initiate studies for solutions to maintain a desirable level of service. For buffered or contiguous HOV facilities, Caltrans

considers LOS-C occurs at approximately 1,650 vehicles per hour, less if there is significant bus volume or if there are physical constraints.

Increasing the occupancy requirement may be the logical solution if adding a second HOV lane is inappropriate. However, going from 2+ to 3+ may reduce vehicular demand by 75% to 85%. Such adjustments may be too severe if only a 10% to 20% reduction in demand is necessary to maintain free-flow conditions. Districts are strongly recommended to involve the FHWA Transportation Engineer and Headquarters HOV Coordinator if a significant change in existing HOV operations is considered. See FHWA Program Guidance at: <http://www.fhwa.dot.gov/legisregs/directives/policy/hovmemgd.htm>.

Varying occupancy requirements, such as the El Monte Busway on Interstate 10 in Los Angeles County, by time of day is a useful option and could be used in conjunction with computer traffic surveillance and technology currently being implemented by the urban Districts. To avoid public confusion over varying occupancy requirements, it is essential that signs and other motorist information devices clearly relate the necessary message. Changing occupancy requirements, whether permanently or by time of day, is enforcement sensitive and should be coordinated with the California Highway Patrol.

Once a decision has been made to change the occupancy requirement, an intense public information and education effort should precede actual implementation. An adequate period should be allowed for public comment and response.

## Section 2.6 Vehicle Types

The Federal Surface Transportation Assistance Act of 1982, in part, permits motorcycles in HOV facilities unless their presence creates a safety hazard. If a documented engineering analysis indicates that motorcycles present more of a safety problem in the HOV facility than in the mixed-flow lanes, then consideration should be given to restricting motorcycles from the HOV facility. Prohibition of motorcycles

requires approval by the U.S. Secretary of Transportation through the Federal Highway Administration, see Appendix A-11. The Districts are advised to consult with Headquarters Traffic Operations when such prohibitions are being considered. Exclusions and changes concerning vehicle types in HOV facilities must be approved by the Director per a December 4, 1989 internal memorandum signed by Director, Robert K. Best.

## **Section 2.7 Deadheading**

The term “deadheading” refers to the use of a HOV facility by transit vehicles occupied only by the driver. Per state legislation, mass transit vehicles were allowed to deadhead effective January 1, 1998 and clearly marked paratransit vehicles were allowed effective January 1, 2003, see Appendix A-7.

## **Section 2.8 Incident Handling/Special Events on HOV Lanes**

### **Section 2.8.1 Incident Handling**

Since the HOV facility is designed to operate at a higher level of service (LOS) than adjacent mixed-flow lanes during commute periods, it is important to isolate the performance patterns of the system. As traffic operations systems (TOS) elements are developed or upgraded in the metropolitan areas, it is essential that such systems provide discrete HOV performance data, e.g. speeds, volumes and lane occupancies so that adjustments can be made to maintain the desirable LOS.

The TOS design should include incident detection verification and handling capabilities for the HOV facility. Frequently, incidents in the HOV lane will result in HOV traffic merging into the adjacent mixed-flow lane. In most cases, the mixed-flow lane should not be closed to mixed-flow traffic and designated a temporary HOV lane. For major incidents in the mixed-flow lanes, Caltrans and the CHP should jointly decide whether to open the HOV facility to mixed-flow traffic.

Freeway Service Patrol (FSP) considerations for HOV facilities should also be an integral element of incident management. This need is particularly acute for barrier-separated HOV facilities, and service patrol activities for the mixed-flow traffic, which do not extend into the HOV facility.

Barrier-separated facilities present different operational problems and possibilities from other types of HOV facilities for handling incidents both in the HOV lane and in the mixed-flow lanes. Incidents in the HOV lane frequently close the lane and require the re-routing of HOV traffic into the mixed-flow lanes. A major incident in the mixed-flow lanes, with multiple lane blockage, may result in utilization of the HOV lane by non-eligible vehicles. Such use of a barrier-separated HOV facility by mixed-flow traffic, particularly for a reversible HOV operation, should be approached with caution. Barrier-separated HOV facilities have very restrictive access points and generally should not be used for incident management unless the incident is of extended duration and where traffic diversion is not possible. If such facilities are to be used, the decision should be made jointly by CHP and Caltrans, who must ensure that all disabled vehicles are removed prior to resuming HOV operation.

### **Section 2.8.2 Special Events**

Special events and weekend traffic normally consist of vehicles with higher occupancy levels than recurrent weekday traffic. Therefore, there should be no need to allow mixed-flow traffic to use a 24-hour HOV facility. For those HOV facilities operating on a part-time basis, consideration should be given to operating the facility as HOV during special events. This would require careful joint planning with the CHP, including the routing of traffic and the use of temporary signing.

### **Section 2.8.3 Agency Responsibilities**

CHP and Caltrans responsibilities regarding incident handling and special events shall adhere to all of the policies contained in the joint operational policy statements.



## Section 2.9 Using HOV Lanes For Traffic Management Plans

Traffic Management Plans (TMPs) are required for all highway activities and in particular for major rehabilitation projects where significant delays are anticipated due to construction. One of the possible TMP elements is the use of an interim HOV lane during reconstruction. The interim lane can be achieved by re-striping or by reconstructing the existing median or shoulder.

There have been several projects nationwide which have included the use of interim HOV lanes as a TMP element including the following:

- A. I-376 in Pittsburgh (Parkway East) - Interim HOV lanes for on-ramps resulted in a 21% increase in the passenger occupancy rate with a 66% reduction in the number of vehicles using the corridor.
- B. I-394 in Minneapolis (US 12) - The installation of the interim HOV lane ("Sane Lane") coupled with free carpool parking in downtown Minneapolis led to a 35% increase in peak hour person-trips.
- C. I-395 in the Washington D.C. Metropolitan area (The Shirley Highway) - During the morning peak periods the HOV lane saved 12 to 18 minutes of commute time when compared to mixed-flow lanes. Within two months, the bus ridership increased by 20%.

## Section 2.10 Passing Lanes

Operational experience in California indicates that vehicular speeds in HOV lanes vary to the extent that passing lanes may be justified. Although trucks are normally excluded from the facility, variations in vehicular speed are such that tailgating occurs with regularity. For those situations, passing lanes should be considered where right of way is not a constraint. Such lanes are particularly appropriate for lengthy buffered or barrier facilities in hilly or mountainous terrain with high bus volumes.

## Section 2.11 Transit Stations

A viable strategy to increase person trips on a HOV facility is to provide express bus service. When planning this service it is often necessary to provide intermediate passenger access when a high level of transit service is desired. Two types of facilities show the most promise in providing access. They are On-Line Transit Stations and Off-Line Transit Stations.

### Section 2.11.1 On-Line Transit Stations

On-Line transit stations are bus transfer facilities located contiguous to the HOV facility. They may serve walk-in passengers from nearby residences or park and ride lots, feeder transit lines or nearby activity centers. Transfers between other express buses operating on the HOV facility can also be accommodated. Stations can be designed to serve either two-way or reversible HOV lanes.

On-Line stations may produce right of way savings, eliminate costly ramp construction that is necessary for off-line stations and provide maximum timesavings. Negative aspects include added noise and air pollution to the users, long walking distances, an increase in transfers between vehicles, and expensive handicap access.

Platform loading facilities may be located in the center of the HOV lanes or on the sides. Center platforms usually require less width, provide for easy transfers, and are less expensive to construct. A major drawback occurs because buses are built to load on the right side of the vehicle. This requires that buses crossover in some manner to orientate themselves for loading. It is necessary for both types that bypass lanes be provided through the platform location to allow other HOVs to proceed without delay.

### Section 2.11.2 Off-Line Transit Stations

Off-Line transit stations are bus facilities, which are not contiguous to the HOV facility, but are close enough to receive direct bus service. They could be located at

nearby park and ride lots, at large employment centers, or be a major transit center.

A major cost in providing service to an off-line station is the necessity of constructing either direct connector ramps or a drop-ramp facility. There could also be a considerable time penalty involved in serving this type of facility when compared to an on-line station. Many of the problems involving on-line stations such as pedestrian access, platform location, and other amenities can more easily be resolved with off-line stations.

Each corridor will require detailed studies to determine which type of station should be constructed to provide the desired transit service. Early consultation with the Project Development Coordinator and Headquarters Traffic Reviewer is recommended when transit stations are being considered.